FINAL TECHNICAL REPORT

ONR GRANT # N00014-93-I-0150

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PARTICULATE OPTICAL CLOSURE: RECONCILING OPTICAL PROPERTIES OF INDIVIDUAL PARTICLES WITH BULK OPTICAL PROPERTIES.

I concluded the development of and published a model to predict spectral phytoplanktonic absorption coefficients from spectral reflectance measured just beneath the sea surface (*Roesler and Perry. 1995. J. Geophys. Res. in press*). In addition, the model can be used to estimate the bulk particulate scattering coefficient and the spectral emission of solar stimulated chlorophyll *a* fluorescence from surface waters. This model was shown to be successful in waters over a large dynamic range of optical properties from Puget Sound to the gyre waters of Oregon.

In situ measurement of spectral absorption and attenuation coefficients in East Sound Orcas Island, Washington were successfully performed in May 1993 with a WET Labs AC-9-25 (*Roesler and Zaneveld. 1994. SPIE Ocean Optics XII 2258: 309-319*). The *in situ* absorption coefficients compared well with those measured spectrophotometrically on the particulate and dissolved fractions of water samples. The *in situ* scattering coefficients (derived by the difference of attenuation and absorption) compared well with those derived from measured particle size distributions and Mie scattering theory. A model to extract the phytoplanktonic absorption signal from the total absorption signal (*Roesler et al. 1989. Limnol. Oceanogr. 34: 1510-1525*) was applied to the *in situ* absorption profiles and resulted in profiles of absorption due to phytoplanktonic and non-phytoplanktonic components. These two components were found to be incoherent with respect to depth. The non-phytoplanktonic component was coherent with the particulate scattering coefficient with respect to depth.

Profiles of *in situ* size-fractionated spectral absorption coefficients were measured with a WET Labs AC-9-25 off the coast of Oregon in 1994. Filter cartridges of various pore sizes (0.2, 3.0 and 20 μm) were placed on the input port of the absorption meter to fractionate the total absorption. The phytoplankton absorption model discussed above (Roesler et al. 1989) was applied to the absorption profiles for each fraction. The result was the first ever profiles of size fractionated absorbing components *in situ*. At one site near the Columbia River Plume it was discovered that the size-fractionated populations of phytoplankton were distributed incoherently with depth. The greater than 20 μm size fraction was dominated by fucoxanthin-rich phytoplankton identified as large chain forming diatoms which were distributed throughout the 15m mixed layer. Beneath the mixed layer, a subsurface maximum of 0.2 to 3 μm diameter phycoerithrin-rich cells was observed and identified to be either Synechococcus or Cryptomonads. Below the euphotic zone the dominant absorbing material was found to be in the less than 0.2 μm fraction (gelbstoff). The manuscript based upon these results is in preparation.

Experiments were performed on eight species of diverse phytoplankton to determine the change in optical properties associated with growth irradiance. Preliminary analysis of the data indicate that the chlorophyll-specific absorption coefficient decreases as growth irradiance decreases, as has been shown previously in the literature. The chlorophyll-specific scattering spectra for algae grown under saturating and limiting irradiance exhibited significantly different spectral slopes at 99% confidence for triplicate cultures of the chlorophytic alga *Dunaliella salina*, for example. The size distributions for this alga exhibited a shift in median diameter from 5.6 to 6.6 μm for growth in high to low irradiance. This shift in population size was not sufficient to explain the difference in the spectral slopes in the scattering efficiency spectra using the van de Hulst approximations of Mie theory. The implications for such variations in algal inherent optical properties under varying growth conditions are significant when interpreting vertical profiles absorption and scattering measured *in situ*. The manuscript based upon these results is in preparation.

LIST OF PUBLICATIONS

Roesler, C.S. and J.R.V. Zaneveld, 1994. High resolution vertical profiles of spectral absorption, attenuation, and scattering coefficients in highly stratified waters. SPIE Ocean Optics XII, 2258: 309-319.

Roesler, C.S. and M.J. Perry, 1995. *In situ* phytoplankton absorption, fluorescence emission, and particulate backscattering spectra can be predicted from spectral reflectance. In press, Optical Closure Issue of J. Geophys. Res.

Bricaud, A., C.S. Roesler, and J.R.V. Zaneveld. 1995. *In situ* attenuation, absorption, and backscattering properties of oceanic and coastal waters off Oregon. In press, Limnol. Oceanogr.

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FINAL REPORT
N00014-93-I-0150
TITLE: PARTICULATE OPTICAL
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PROP. OF INDIVIDUAL PARTICLES
W/BULK OPTICAL PROPERTIES

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